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IMBRICATIVE ÆSTIVATION.

BY A. P. MORGAN.



1. THE arrangement of the different parts of the flower in the bud is called *æstivation* or *præfloration*. Æstivation has reference chiefly to the relative arrangement in the bud of the sepals and petals. The æstivation of the floral envelopes passes by several gradations from the regular alternate arrangement of leaves, in which the parts are situated at different heights one above another, to the complete whorled arrangement in which the parts are all placed at the same level, edge to edge.

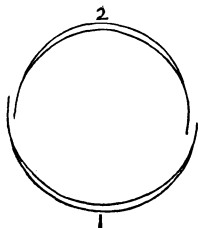
2. There are distinguished three principal kinds of æstivation denominated respectively the *imbricative*, the *contortive* and the *valvular*. The latter presents no variety except the infolding of the edges of the leaves which, however, does not concern their relative arrangement in the bud; and contortive æstivation exhibits no variation except in the direction of the twist which may be either from left to right or from right to left. It is our purpose to give an analysis of imbricative æstivation and to endeavor to systematize its variability.

3. In *imbricative æstivation* some parts of the floral whorl overlie others like shingles on a roof: that is, certain parts are wholly external while others are wholly internal. There is usually a more or less evident spiral arrangement of the parts; the spiral making one or more turns to form the whorl. When the direction of the

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spiral in all the flowers of plants of the same kind is uniformly from left to right or with the hands of a watch, the parts of the whorl may be termed imbricate+; when the direction of the

Fig. 110.



spiral is uniformly from right to left or contrary to the hands of a watch, the parts are imbricate—. If, however, the spiral does not maintain a uniform direction, but winds in some flowers of the plant to the right and in others to the left, the parts of the whorl may be termed imbricate±.

4. Imbricative æstivation is the most common arrangement of both sepals and petals. It admits of much variety dependent upon the number and the relative position of the external and internal parts. Also, this variety of arrangement is displayed much more in the corolla than in the calyx.

5. In a dimerous imbricate whorl, the two edges of one part overlap both edges of the other part (Fig. 110), as in the calyx of the Spring Beauty (*Claytonia Caroliniana*). This is an alternate two-ranked arrangement.

6. In a trimerous imbricate whorl, one part is wholly external, one is wholly internal and the third is intermediate, that is, has

Fig. 111.

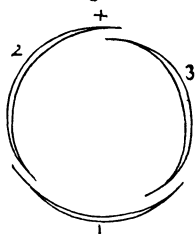
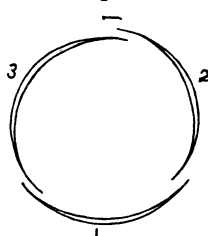


Fig. 112.



one edge in and the other edge out, as in the calyx and corolla of *Trillium*. Here there is an obvious spiral arrangement and the successive members of the cycle may be numbered 1, 2 and 3.

The spiral makes a single turn to the right or to the left according as 3 lies to the right or left of 1, and the whorl is imbricate+ (Fig. 111), or imbricate— (Fig. 112), accordingly. This is the 3-ranked or $\frac{1}{3}$ arrangement of leaves.

7. A tetramerous imbricate whorl presents two cases. In the

first case two opposite parts are wholly external, and the other two opposite parts are wholly internal (Fig. 113), as in the calyx of cruciferous flowers. This is the case of opposite decussate leaves. In the second case one part is external, one internal, and

Fig. 113.

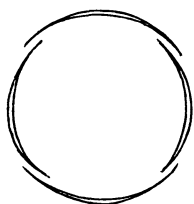


Fig. 114.

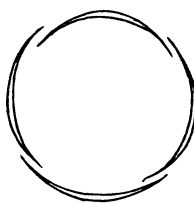


Fig. 115.

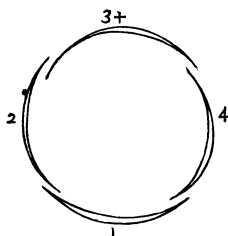
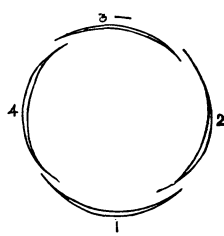


Fig. 116.



the other two intermediate. In this case there are two varieties, according as the internal part is opposite or adjacent to the external part. When the internal part is adjacent, there is an evident spiral arrangement. Numbering the parts 1, 2, 3 and 4,

Fig. 117.

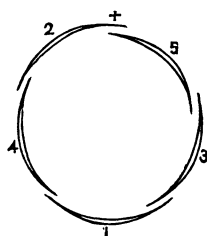
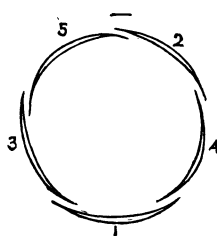


Fig. 118.



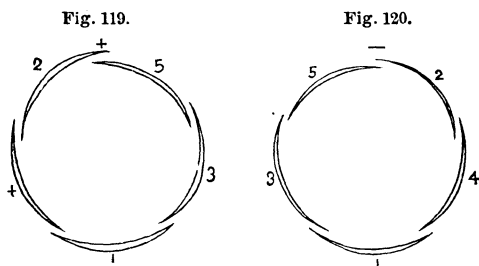
the spiral makes one turn to the right (Fig. 115), or to the left (Fig. 116), according as 4 is on the right or left of 1. This is the common arrangement of the petals of cruciferous flowers. The internal part may sometimes be seen opposite (Fig. 114) in

the same flowers; this is the arrangement of the four sepals of the White Water Lily (*Nymphaea odorata*).

8. A pentamerous imbricate whorl, also, presents two cases.

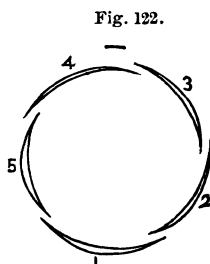
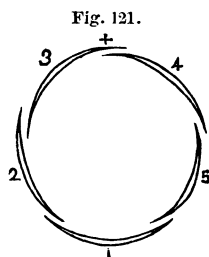
I. Two parts of the floral whorl are external, two parts are internal and one is intermediate (Figs. 117, 118). This is regular pentamerous imbrication. It corresponds to the quincuncial or $\frac{2}{5}$ arrangement of leaves. The spiral makes two turns to form the whorl. The successive members of the cycle may be numbered 1, 2, 3, 4 and 5 (Figs. 117, 118). 1 and 2 are the external parts; 4 and 5 are the internal parts; and 3 is the intermediate part. 1 has 3 and 4 adjacent and 2 and 5 opposite. One edge of 3 is covered by the adjacent edge of 1, while the other edge of 3 overlaps the adjacent edge of 5. The succession of the numbers of the cycle in the whorl, in one direction, is 1, 4, 2, 5, 3; in the other direction, 1, 3, 5, 2, 4. 3 shows the direction of the spiral; when it lies on the right of 1, the spiral winds from left to right, and the parts of the whorl are imbricate + (Fig. 117); when it lies on the left of 1, the spiral winds from right to left, and the parts are imbricate — (Fig. 118).

II. One part of the floral whorl is external, one part is internal and three parts are intermediate. This is irregular pentamerous imbrication. There are two varieties of this case, according as the internal part is opposite or adjacent to the external part.

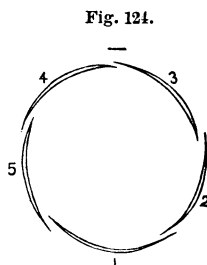
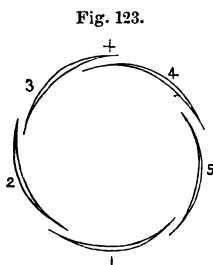


When the internal part is opposite (Figs. 119, 120) there is still a spiral cycle of two turns; but the part 4 by a slight torsion, throws out one edge over the adjacent edge of 2; so that 2 and 4 have one edge out and one edge in, the same as 3: 3 lying between 1 and 5 still shows the direction of the spiral. This is the æstivation of papilionaceous flowers. In these the large petal called the vexillum or banner overlaps the others, and on this ac-

count this variety has been termed *vexillary* imbrication. This variety of imbrication, however, occurs frequently in the flowers of many plants along with the regular imbrication, as shown in the examples of *Rubus odoratus* and *Pyrola elliptica* (Tables I and II). When the internal part is adjacent to the external part



(Figs. 121, 122), the spiral makes but a single turn to form the whorl. The direction of the spiral is shown by 5 lying on the right or on the left of 1. This second variety is perhaps to be met with only as a casual variation from the other modes. I know of no flowers in which it is the only mode of æstivation, but the extent to which it occurs in many flowers is shown by the example of *Rubus odoratus* (Table I).



9. The second variety of irregular imbrication passes easily into contortive æstivation by 5 throwing out one edge over 1. This also is shown by some of the flowers of *Rubus odoratus* passing into the contorted mode.

10. The imbrication of the flower sometimes shows a fixed relation to the axis, and whether there be such a relation or not, needs to be carefully observed. When the inflorescence is definite the flower terminates the axis and of course there is no other relation. Hence the position of the external and internal parts is

immaterial in diagram. When the inflorescence is indefinite, however, the external petal sometimes maintains a fixed relation to the axis. For instance, in papilionaceous flowers, the external petal is always the posterior one. In the violet the external petal may be either the right or left upper petal, the lower spurred petal being always internal. In many plants on the contrary, some of the flowers commence the spiral at one part of the whorl, and other flowers at other parts of the whorl. This is shown by the example of *Pyrola elliptica* (Table II.)

11. For the purpose of observing and recording the mode of imbrication in a pentamerous flower for example, rule a table as follows (Table I) :

In the Table, I denotes the first case or regular imbrication ; II denotes the second case or irregular imbrication ; while 1 and 2 indicate the first and second variety of II. Each example is marked by the direction of the spiral. Summing up the observations of 100 flowers of *Rubus odoratus*, examined for the illustration of this article, they show the following variety of arrangement :

Calyx, imbricate.

Case I. $+ 54, - 46$. Total, 100.

Corolla, imbricate.

Case I. $+ 22, - 10$. Total, 32.

Case II.

1 v. $+ 14, - 13$. Total, 27.

2 v. $+ 20, - 13$. Total, 33.

Corolla, contorted,

$+ 4, - 4$. Total, 8.

Total $+ 60, - 40$.

TABLE I.
Rubus odoratus L.

No. of Spec.	Calyx, imbricate.			Corolla, imbricate.		
	I	II		I	II	
		1	2		1	2
1	—				+	
2	—					+
3	+				—	
4	—				—	
5	+			—		
6	+					—
7	+				+	
8	+			+		
9	+				—	
10	+					+
11	—					+
12	—				+	
13	—				—	
14	+			+		
	+					—

[TABLE II.] CASE I.

No.	1	2	3	4	5
3	l	p'	a	p	l'
12	l	l'	p	a	p'
18	l'	l	p'	a	p
4	l'	p	a	p'	l
16	p	l'	l	p'	a
2	p	a	p'	l	l'
3	p'	a	p	l'	l
3	p'	l	l'	p	a
10	a	p	l'	l	p'

CASE II. 1.

4	l	l'	p	a	p'
1	l	p'	a	p	l'
5	l'	p	a	p'	l
1	p	l	l'	p	a
2	p	a	p'	l	l'
2	p'	l	l'	p	a
2	p'	a	p	l'	l
5	a	p'	l	l'	p

CASE II. 2.

3	l'	p'	p	l	a
3	l	a	l'	p'	p
1	a	l'	p'	p	l

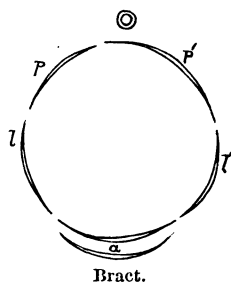
12. For the purpose of observing and recording both the imbrication of the whorl and the relation of its parts to the axis, I make a diagram of the flower (Fig. 125) and rule a table as on the opposite page (Table II) :

In this diagram of the corolla of *Pyrola elliptica* (Fig. 125) *p* and *p'* denote the upper or posterior petals ; *l* and *l'* the lateral petal ; and *a*, the anterior or lower petal.

In Table II the figures 1, 2, 3, 4, 5 represent the successive parts of the spiral. The Table shows the summing up of one hundred observations of the imbrication of the corolla of *Pyrola elliptica* Nutt.

Fig. 125.

Axis.



THE METAMORPHOSIS OF FLIES.* III.

BY DR. AUGUST WEISSMANN.

WHAT appears most unusual in the development of the Muscidæ is the genesis of the thorax and head together with their appendages. That this section of the fly's body is completely formed anew, not standing in genetic connection with the corresponding parts of the larva, contradicts the generally accepted and long prevalent view, according to which pupation is only a moulting process. As little does this opinion agree with the fact of the total transformation which all the inner organs suffer during pupation. All the systems of the organs of the larva die, in part completely, in part cell by cell, in order afterwards to be built up anew.

Evidently the metamorphosis of *Corethra* stands in diametrical opposition to this mode of development, and indeed to the two previously described main points. Here the pupation may be rightly regarded as a moulting process ; we see no phenomena de-

*Being the concluding chapter of "Die Metamorphose der *Corethra plumicornis*, ein weiterer Beitrag zur Entwicklungsgeschichte der Insecten. Von Dr. August Weissmann. Mit. 5 Kupfertafeln. Leipzig, 1866. 8vo, pp. 83.